植物分类学报 42(3):222 – 235(2004)
Acta Phytotaxonomica Sinica

A multivariate morphometric study on *Corylus sieboldiana* complex (Betulaceae) in China, Korea, and Japan

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Abstract Previous taxonomic treatments in Russia and China have considered *Corylus mandshurica* and *C. sieboldiana* to be distinct as independent species. A morphometric analysis was conducted to determine if the morphological differentiation from these taxa warrants specific taxonomic recognition with a large sample of field-collected leaves as well as specimens from several herbaria of northeastern Asia. One hundred and fifty two individuals representing Chinese, Korean, and Japanese geographic ranges of the species were scored for 18 morphological characters and the data matrix was used for principal components analysis. The entities that comprise *C. sieboldiana* complex exhibit widely overlapping ranges in all morphological attributes. The leaf and fruit data may reflect a lack of divergence between taxa. Therefore, we do not regard these to be sufficient for taxonomic splitting of *C. mandshurica* from *C. sieboldiana* to warrant the designation of the rank of a species based on morphology. The two taxa were not morphologically well differentiated and their ranges of distribution come together. Therefore, *C. mandshurica* should be recognized as an infraspecific taxon of *C. sieboldiana*. *C. sieboldiana* with short involucres in southern Korea and Japan is often treated as an independent species (*C. hallaisanensis*) or a variety (*C. sieboldiana* var. *brevirostris*), but should be only recognized as a form of *C. sieboldiana* because this involucral character is highly variable even within the same individual.

Key words *Corylus sieboldiana* complex, morphometric principal components analysis, taxonomic treatment.

Corylus L. is a wide-ranging genus of trees and shrubs comprising up to 15 (Furlow, 1990) or 20 (Rehder, 1927) species throughout the Northern Hemisphere with most of the species distributed in Eurasia. Although many significant contributions on hazelnut phylogeny have been made in DNA studies (Forest & Bruneau, 2000; Erdogan & Mehlenbacher, 2000; Whitcher & Wen, 2001), most results have proposed only the broad outlines of a phylogeny for extant taxa.

Infrageneric classifications of *Corylus* have recognized either two or three main divisions as sections or subgenera (Furlow, 1990; Whitcher & Wen, 2001). The ITS phylogeny (Whitcher & Wen, 2001) supported the recognition of two sections (*Acanthochlamys* Spach and *Corylus*) with section *Corylus* being divided into three subsections (*Corylus*, *Colurnae* Schneid. and *Siphonochlamys* (Bobrov) P. C. Li) (Forest & Bruneau, 2000). However, many taxonomists often recognized two subsections within sect. *Corylus* primarily based on the morphology of the involucre surrounding nut (de Candolle, 1864; Schneider, 1916; Furlow, 1997). *Corylus sieboldiana* Blume and *C. mandshurica* Maxim. & Rupr. belong to sect. *Corylus*, subsect. *Siphonochlamys* (sensu Furlow, 1997; Li & Cheng, 1979) due to tubular involucre.

Received: 27 May 2003 Accepted: 5 March 2004.
Supported partly by a grant from Plant Diversity Research Center of 21st Frontier Research Program funded by Ministry of Science and Technology of Korean Government (Grant No. PF001302-00).

Species delimitation in the *C. sieboldiana* complex has been discussed by several authors (Schneider, 1916; Kitamura & Murata, 1984; Ohwi, 1984; Fu et al., 2000; Charkevicz, 1996), but is still debatable. *C. sieboldiana* var. *sieboldiana*, *C. sieboldiana* var. *brevirostris* Schneid., *C. mandshurica*, and *C. hallaisanensis* Nakai are here collectively referred to as the *C. sieboldiana* complex.

After Blume first recognized *C. sieboldiana* in Japan, several infraspecific taxa, var. *mitis* Nakai, var. *brevirostris* Schneid., and var. *mandshurica* (Maxim. & Rupr.) Schneid., were distinguished by the size of fruit, leaf shape, leaf length, and shape of involucre (Schneider, 1916; Kitamura & Murata, 1984; Ohwi, 1984). Maximowicz and Ruprecht (1856) considered *C. mandshurica* as a distinctive species, while Schneider (1916) treated *C. mandshurica* at the infraspecific rank of *C. sieboldiana*, i.e., *C. sieboldiana* var. *mandshurica*. Recent floras in Russia (Charkevicz, 1996) and China (Li & Cheng, 1979; Li & Skvortsov, 1999; Fu et al., 2000) presented arguments favoring recognition of this taxon as a species. However, Japanese and Korean taxonomists (Kitamura & Murata, 1984; Lee, 1980; Ohwi, 1984; Lee, 1996) differed from Chinese and Russian botanists in reducing *C. mandshurica* to a variety of *C. sieboldiana*. Two major treatments regarding *C. sieboldiana* and *C. mandshurica* differed from each other primarily in their recognition of four morphological characters: leaf shape, leaf serration, involucre width, and involucre length. *C. sieboldiana* is characterized by its obovate-oblong leaves that are rounded at base and more or less gradually pointed at apex with acute serration. On the other hand, *C. mandshurica* is characterized by its orbicular-ovate leaves that are more truncate at apex and mostly coarser, shorter and broader lobed above the middle. The involucre of *C. sieboldiana* is contracted above the nut into a narrower tube, while that of *C. mandshurica* is less contracted (Nakai, 1915; Schneider, 1916).

Besides these two taxa, Nakai (1915) described the taxon with very short involucres and treated it as a new species, *C. hallaisanensis* based on Taquet's collections from Island Jeju-do of South Korea, but Schneider (1916) designated it as *C. sieboldiana* var. *brevirostris*. The regional flora (Lee, 1980; Lee, 1996) in Korea supported Nakai's circumscriptions and still maintained this taxon at the specific level. On the other hand, *C. sieboldiana* var. *mitis* Nakai is characterized by its small fruits with a very narrow tube and a yellow-brownish pubescence mixed with a few setose hairs (Schneider, 1916; Nakai, 1915), but has been currently recognized under *C. sieboldiana* var. *sieboldiana* as one polymorphic species in Japan (Ohwi, 1984; Kitamura & Murata, 1984) due to the continuous variation of involucre width.

It is quite evident that a major difficulty in the taxonomy of the *C. sieboldiana* complex has been the exclusive use of minor differences in fruit morphology as well as leaf characteristics for species definition and recognition. The confusion regarding the species delimitation was due to the great variability of this complex from China to Japan through Korea. There is a clear need for a study of this complex that goes beyond the limited work that has been done previously as a small part of a major floristic endeavor thus far.

The primary objective of this research was to redefine the phenetic relationships among the different morphological entities of the *C. sieboldiana* complex. Particular attention was focused on *C. mandshurica* and *C. sieboldiana* in southern part of Korea which are quite different from *C. sieboldiana* in Japan and *C. mandshurica* in northern part of Korea and northeastern China because of the high degree of morphological intergradation among the entities and the inconsistent circumscription. It was also conducted to determine if the morphological differentiation among the *C. sieboldiana* complex warrants specific taxonomic recognition with a large sample of field-collected leaves as well as the pattern of geographical distribution. The effects of polymorphic level on leaf shape and fruit size were investigated to determine the constancy of the characters.

1 Material and Methods

Specimens of *Corylus sieboldiana* var. *sieboldiana* and *C. sieboldiana* var. *brevirostris* were obtained from University of Tokyo (TI), Tokyo Metropolitan University (MAK), Institute of Applied Ecology, the Chinese Academy of Sciences, Shenyang (IFP), and Cheonnam University as loans as well as the Arboretum of Seoul National University (SNUA). Mature leaves of *C. mandshurica*, which have been deposited at SNUA, were collected in many places in Korea and Japan from 1998 to 2002. Herbarium specimens of *C. sieboldiana* and *C. mandshurica* were selected to represent the entire geographical range of Northeast China, Korea and Japan and to reflect the morphological variability within each taxon. However, some specimens in Korea were almost indistinguishable morphologically from both *C. sieboldiana* var. *sieboldiana* and *C. mandshurica* and these were referred to as the intermediate type for analysis. Therefore, two varieties of *C. sieboldiana* and *C. mandshurica* were defined and analyzed here. Illustrations of the leaf and fruit morphologies (Fig. 1) were adapted from Nakai 's drawing of *C. sieboldiana* (Nakai, 1915).

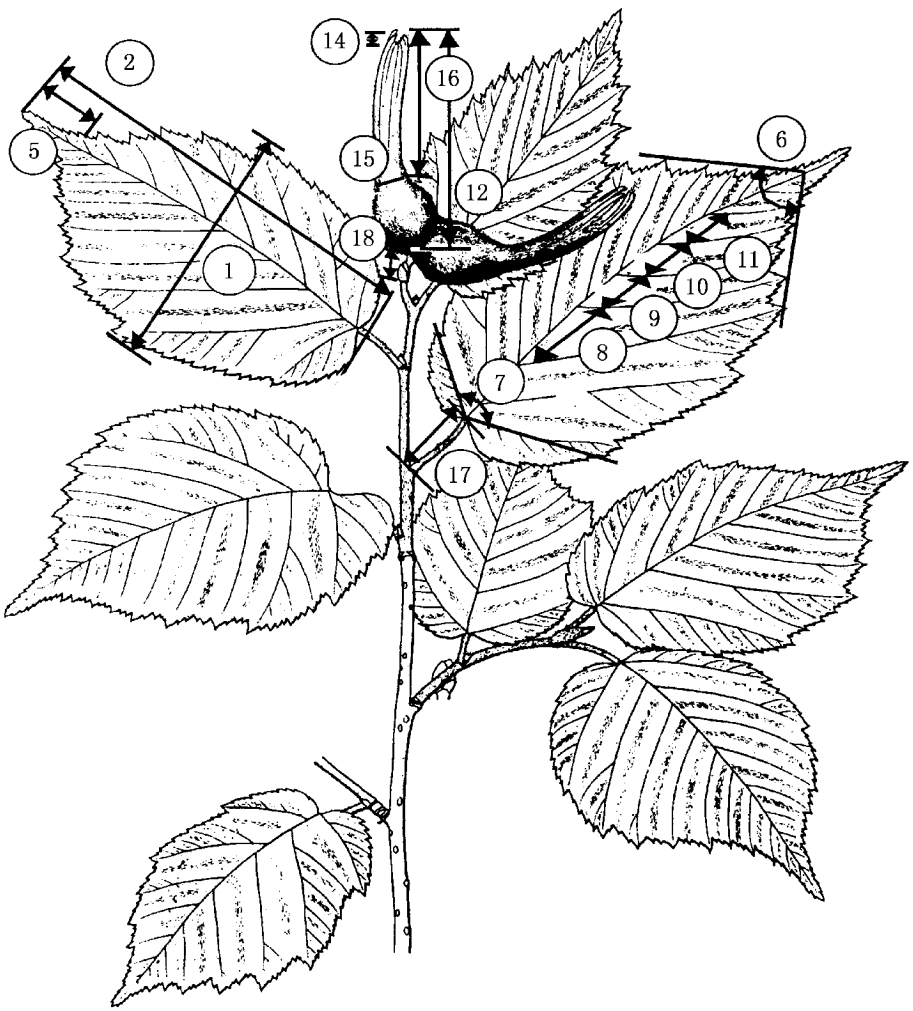

Fig. 1. The representative measured characters for the morphometric analysis (from Nakai, 1915).

Characters selected for analyses included those most frequently utilized in keys and diagnoses of the various taxa. Characters considered useful by other authors (Schneider, 1916; Kitamura & Murata, 1984; Lee, 1980; Ohwi, 1984; Charkevicz, 1996) for reliable identification were also selected. For leaf measurements a "typical" and usually the largest measurable leaf was selected. The initial data matrices were constructed from 18 characters (Table 1). Measurements were made with a ruler and a binocular micrometer. One hundred and fifty two individuals of *C. sieboldiana* (74), *C. mandshurica* (54), and the intermediate type (24) were measured for the various attributes. All specimens used in the analyses were in a mature stage of development.

Criteria classically used in floras to distinguish between *C. sieboldiana* and *C. mandshurica* concern differences in leaf shape and in involucre of the fruits (Kitamura & Murata, 1984; Ohwi, 1984; Lee, 1980; Lee, 1996), but those traits do not clearly discriminate between the two species because the variation of the traits is widely overlapped (see results). Therefore, based on the criteria described by Schneider (1916), an individual of *C. mandshurica* observed in eastern Korea and northeastern China represents the same characteristics as a plant of *C. mandshurica* in China and Russia. Our approach consists of a study of individuals in northeastern China and eastern Korea and individuals in Japan that we have classified, *a priori*, as *C. mandshurica* and *C. sieboldiana* respectively. We then test *a posteriori* the capacity of measured characters to differentiate both groups of individuals. Finally, we examine results from the only sites we found where the two species are sympatric. Here we have found individuals ("intermediate" plant) presenting some of the characteristics of each species. Intermediate plants for the characters measured are of special importance in testing the validity of our analysis.

Morphological variation within and among the taxa was assessed using univariate statistics

Table 1 Characters used in morphological analysis of *C. sieboldiana* complex*

Leaf	1	Width
	2	Length
	3	Number of leaf veins
	4	Number of serration in the apex
	5	Length of apex
	6	Angle of apex
	7	Angle of base
	8	Length between leaf veins
	9	Length between leaf veins I (I)
	10	Length between leaf veins II (J)
	11	Length between leaf veins III (K)
	17	Length of petiole
Fruit	12	Length of fruit
	13	Number of serration of involucre
	14	Length of serration of involucre
	15	Width of lower part of involucre
	16	Length of involucre (except nut)
	18	Length of peduncle

* The numerals represent the same characters as shown in Fig. 1.

(mean, maximum, minimum) and multivariate morphometric analyses (PCA) with SAS program (SAS Institute Inc., 1988). A correlation matrix was generated using selected significant characters along with analysis of variance (ANOVA) and univariate analyses. Also, bivariate analyses (bivariate scatter diagrams) were performed and each character associated with individuals of three OTUs (Operational Taxonomic Units), *C. mandshurica*, *C. sieboldiana* and intermediate type, were plotted here.

2 Results

In principal components analysis, the first three factors accounted for 39.1%, 11.3%, and 9.4% of the total variance respectively, or 59.8% altogether. PC1 had the highest loadings for leaf width (1) and length (2) and distance between lateral veins (9 to 11); PC2 had the highest loadings for fruit length (12), involucre length (16), serration depth of involucre (14), and width of lower part of involucre (15), and PC3 had the highest loadings for number of lateral veins (3) and peduncle length (18). PC1 provided more separation between *C. sieboldiana* and *C. mandshurica* than PC2 and PC3 did. Leaf size and the distance between leaf veins were important characters that permit the differentiation of these taxa. A plot on the second and third principal components, which were related to characters of fruit, failed to establish discrete groups. Results of the PCA showed that *C. sieboldiana* and *C. mandshurica* (Fig. 2) were not morphologically distinct with morphological continuum. Indeed, the material of *C. mandshurica* in south Korea remains as a problematic entity due to its morphological similarity to *C. mandshurica* and *C. sieboldiana*.

Univariate statistics, in addition to the minimum and maximum values for other characters (Fig. 3) showed that values overlapped extensively for these two taxa. The high correlation coefficients were found in several characters, such as, leaf length vs. width, and fruit length vs. involucre length.

It is clear that *C. sieboldiana* and *C. mandshurica* are largely separated by the leaf length and width (Schneider, 1916), i.e., the former elliptic, the latter oval except the intermediate (Fig. 4). If the intermediate individuals were included for the analysis, no strong discontinuities exist between two taxa with respect to several diagnostic leaf characters. Much overlap between taxa occurred in the central region of the scatter diagram as well as PCA (Figs. 2, 4).

Some individuals of *C. mandshurica* in south Korea are not greatly separated from the two taxa, because they possess both the typical oval leaf of *C. mandshurica* and the elliptic leaf of *C. sieboldiana* within the same twig for leaf morphology.

Besides the relationship between *C. mandshurica* and *C. sieboldiana* var. *sieboldiana*, *C. sieboldiana* var. *brevirostris* and *C. hallaisanensis*, which have very short involucre, remained as problematic taxa. The frequency distribution for involucre length (Fig. 5) was examined in order to test whether or not it was a diagnostic character for discrimination between taxa with short vs. long involucre length. It revealed that distribution of the two species for this character overlapped considerably more. Also, the separation of individuals with short length of involucre and those with intermediate length of involucre on the distribution could not be considered entirely significant. Therefore, there was virtually no separation of taxa with respect to the length of involucre tube.

3 Discussion

Corylus mandshurica in north and eastern Korea, northeastern China, and far eastern Russia exhibited only the distinctive leaf shape and involucres (Ohwi, 1984; Schneider, 1916), compared with *C. sieboldiana*. The extreme leaf form of *C. mandshurica* emerged as the most distinct mainly due to the irregularly and coarsely serrate margin, and mucronate-acuminate or caudate apex, while

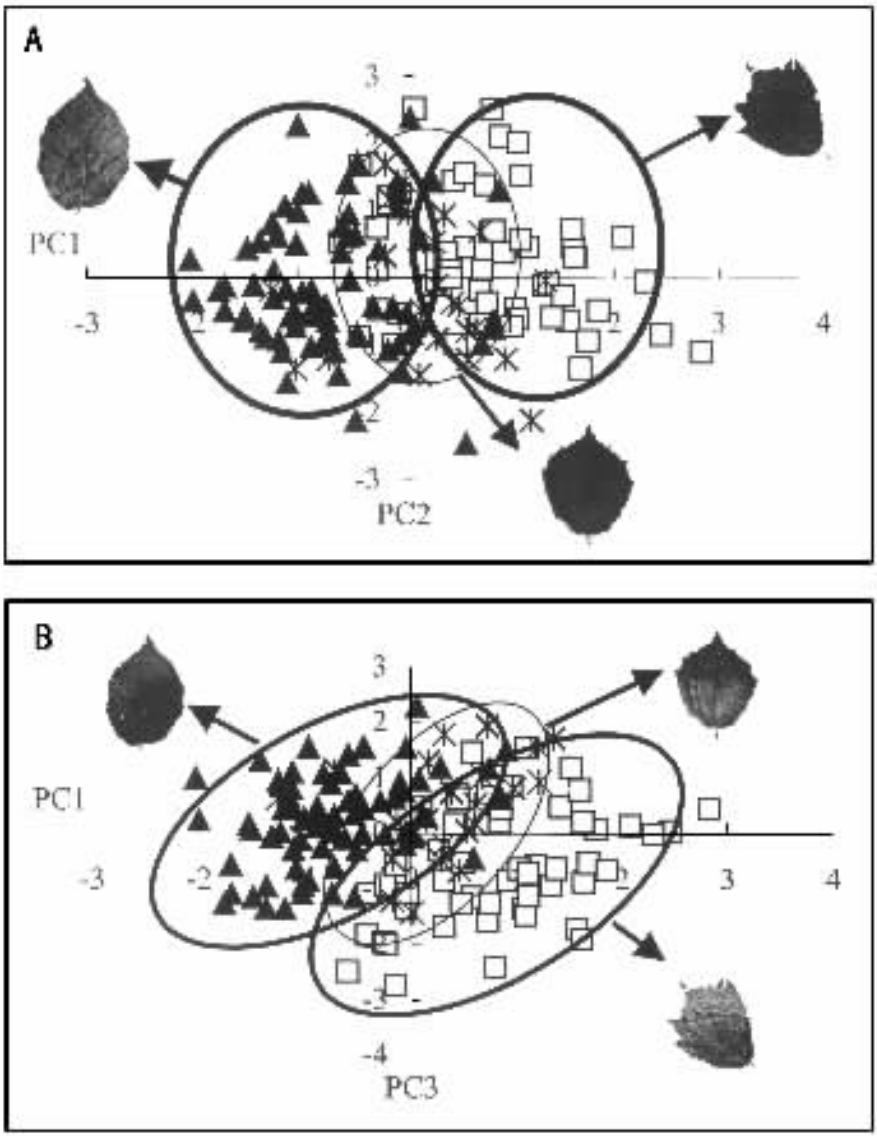

Fig. 2. Scatter diagrams from principal components analysis of *Corylus sieboldiana* complex. **A**, PC1 vs. PC2. **B**, PC1 vs. PC3. □, *C. mandshurica*; ▲, *C. sieboldiana*; *, intermediate.

C. sieboldiana was characterized by its elliptic or oval leaves more or less gradually pointed at the apex and regularly acute-serrate. In fact, Schneider (1916), who treated *C. mandshurica* as an infraspecific taxon of *C. sieboldiana*, indicated that the extreme forms of both taxa looked very distinct.

Our initial examination of herbarium specimens suggested, however, the high degree of morphological intergradation among its entities and its inconsistent circumscription within *C. sieboldiana* complex. The morphometric analysis indicated that no strong discontinuities existed among these taxa. Comparisons of the univariate, conceptually related means and range, pointed up the similarity between *C. sieboldiana* and *C. mandshurica*. Therefore, the morphological

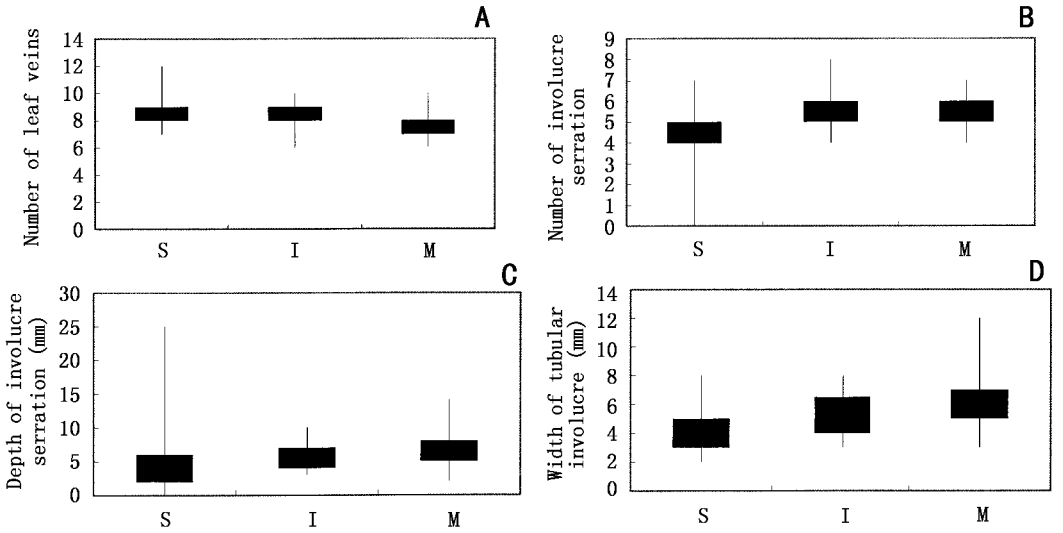

Fig. 3. Character variation of *Corylus sieboldiana* complex. **A,** Number of leaf veins. **B,** Number of involucre serration. **C,** Depth of involucre serration. **D,** Width of tubular involucre. I, intermediate (*C. sieboldiana* of southern Korea); M, *C. mandshurica*; S, *C. sieboldiana*.

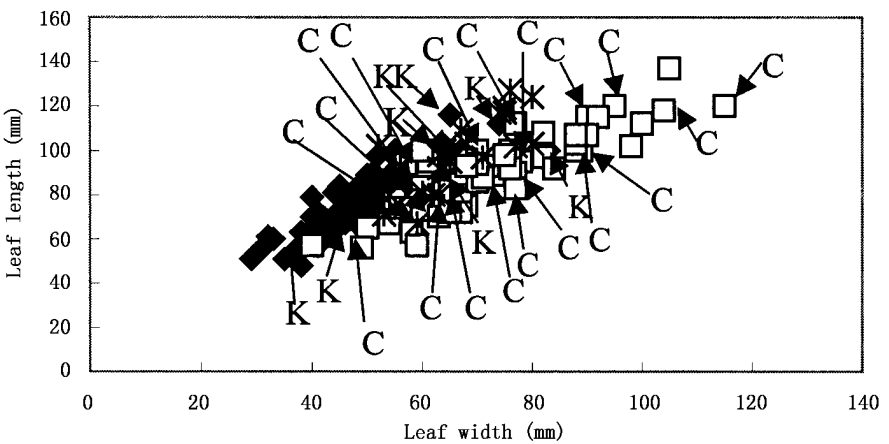

Fig. 4. Scattered plot for leaf length and width of *Corylus sieboldiana* complex. □, *C. mandshurica*; ■, *C. sieboldiana*; *, intermediate; C, China; K, Korea.

continuity among these taxa had prompted questions about their taxonomic status as species or varieties.

Geographic distribution of the species should be taken into consideration along with the analysis of similarities and differences of morphological characteristics as a basis for evaluating relationships among taxa (Radford et al., 1974). The results obtained from this study do not support the separation of *C. sieboldiana* from *C. mandshurica* as an independent species. *C. sieboldiana* seemed to be restricted to southern islands of Korea as well as Japan (Hokkaido to Kyushu) based on observation of herbarium specimens. *C. mandshurica* in southern parts of Korea was intermediate between *C. mandshurica* from northern parts of Korea (Province Ganwg-won-do) and northeastern China and *C. sieboldiana* from Japan and southern islands of Korea in leaf shape. It is shown from this study that variation of the major key characters of *C. sieboldiana* in southern Korea was continuous and overlapping with OTUs of *C. mandshurica* and *C. sieboldiana* from other areas. The

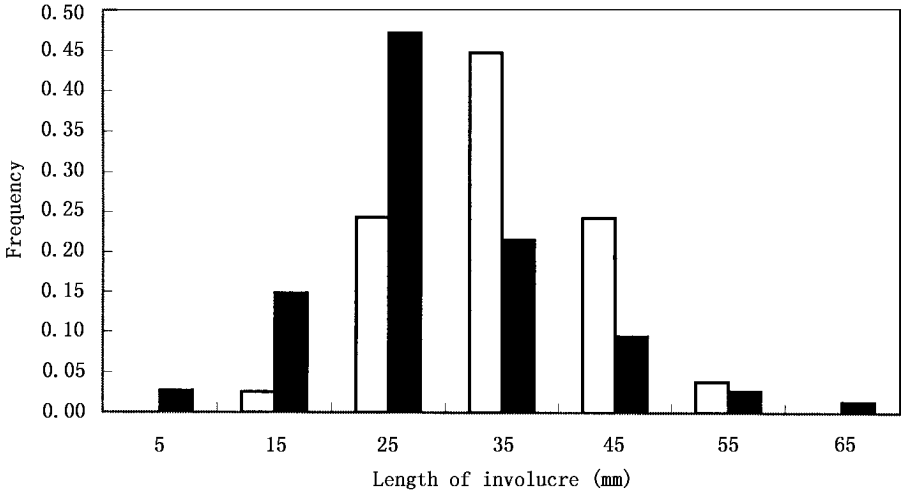

Fig. 5. Frequency distribution of involucral bract length from *Corylus sieboldiana* var. *sieboldiana* (□) and *C. sieboldiana* var. *mandshurica* (■).

difficulties of quantitatively visualizing shape differences could be seen in the unclear distinction among OTUs in southern Korea. Therefore, it exhibited recombination of some traits, resembling both *C. sieboldiana* and *C. mandshurica* in leaf serration, leaf apex, and short involucre tube.

Corylus sieboldiana var. *brevirostris*, which has been recognized as morphologically distinct from *C. sieboldiana* var. *sieboldiana* in Japan, remains as a problematic taxon (Schneider, 1916). A detailed investigation of many individuals of *C. sieboldiana* in Japan revealed a comparable degree of continuous variation of bract length and width. Many specimens of short involucre type (= *C. sieboldiana* var. *brevirostris*) exhibited widely overlapping ranges in the length of involucre with *C. sieboldiana* var. *sieboldiana* (Fig. 2). The frequencies for involucre length (Fig. 3) showed the normal distribution, suggesting this character was related to the polygenic trait. Both observed intrapopulation variation and the presumed simple genetic control of the character would suggest that it is insufficient for recognition of species or infraspecific taxon. Although extreme entity was specific to some individuals, none of these individuals could be reliably, consistently, and geographically identified with the use of this character alone. Therefore, the previously recognized taxon, *C. sieboldiana* var. *brevirostris*, should be united with *C. sieboldiana* along with forms intermediate in fruit and involucre morphology between these two taxa. *C. hallaisanensis*, which was described by Nakai (1915) in southern Korea based on short involucre, has never been compared with *C. sieboldiana* var. *brevirostris* in Japan thus far. When Schneider (1916) described the short involucre type of *C. sieboldiana* as an infraspecific species based on the Japanese individuals, he was not able to examine Nakai 's type specimen (collected from Island Jeju-do of Korea, Nakai, 1915). Therefore, Schneider (1916) never compared the major difference between *C. sieboldiana* var. *brevistoris* and *C. hallaisanensis*. Unfortunately, we were not able to confirm Nakai 's type specimen on *C. hallaisanensis* at TI either and only used Nakai 's drawing (Fig. 2 of Flora Sylvatica Koreana, Nakai, 1915). This study demonstrated that taxa of *Corylus sieboldiana* complex cannot be delimited with the use of leaf morphological characters alone. Therefore, a plausible suggestion is that the entities of this group (= *C. hallaisanensis* and *C. sieboldiana* var. *brevirostris*) should be united and recognized under one taxon, *C. sieboldiana* var. *sieboldiana*.

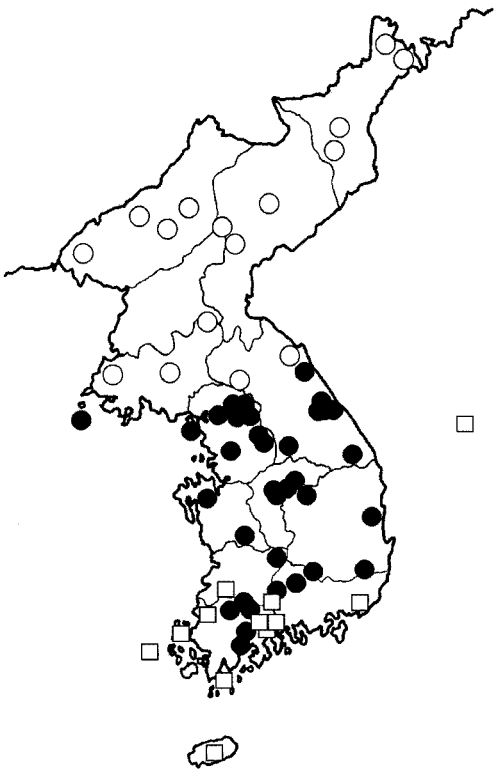

Fig. 6. A map of *Corylus sieboldiana* var. *sieboldiana* (□) and *C. sieboldiana* var. *mandshurica* (○, Chung, 1943; ●, based on specimens of SNUA) in Korea.

According to Li and Cheng (1979), *C. sieboldiana* complex as well as *C. chinensis* Franch. and *C. fargesii* Schneid. were all members of sect. *Corylus*, subsect. *Siphonochlamys*. However, Whitcher and Wen (2001), Forest and Bruneau (2000), and Erdogan and Mehlenbacher (2000) show that *C. chinensis*, which has deeply dissected involucral margins and a tree habit, is phylogenetically different from *C. sieboldiana* complex with respect of ITS phylogeny. On the other hand, the monophyly of *C. mandshurica* and *C. sieboldiana* is strongly supported by the ITS phylogeny (Forest & Bruneau, 2000). Therefore, *C. mandshurica* and *C. sieboldiana* may be of common origin.

The entities that comprise *C. sieboldiana* complex exhibit widely overlapping ranges in all morphological attributes. Consequently, each entity cannot be considered to be consistently distinct. The most cohesive vegetative morphology is largely due to the high level of variability expressed in the leaves. The leaf and fruit data may reflect a lack of divergence between them. We do not believe these to be sufficient for taxonomic splitting of *C. mandshurica* from *C. sieboldiana* to warrant the designation of the rank of a species based on morphology and their origin. The two taxa were not morphologically well differentiated where their ranges of distribution come together (Fig. 6).

In summary, based on our results from the morphometric analyses, *C. sieboldiana* complex is interpreted as one species, *C. sieboldiana*, with one infraspecific taxon, *C. sieboldiana* var. *mandshurica*. Therefore, our systematic interpretation on *C. sieboldiana* complex was in agreement with the taxonomic treatment of Schneider (1916) except *C. sieboldiana* var. *brevistoris*. This study confirmed that *C. sieboldiana* var. *sieboldiana* is distributed in southern Korea as well as in Japan, while *C. sieboldiana* var. *mandshurica* is found in Korea, northeastern China, and far eastern Russia. Although *C. sieboldiana* var. *mandshurica* in Japan has been recorded to occur from Hokkaido (Ohwi, 1984; Kitamura & Murata, 1984, Figs. 6, 7), no material was seen from MAK and TI this time. This locality was not included on the map of distribution of *C. sieboldiana* var. *mandshurica*. Based on our analyses, the following key and taxonomic treatments are provided as follows.

Key to the taxa of *Corylus sieboldiana* complex

1. Leaves elliptic or oval, margin regularly acute-serrate, apex more or less gradually pointed; lateral veins (7) 8 – 9(12) on each side of midvein; tubular involucre shallowly divided into lobes, lobes (0) 2 – 6(8) mm long; narrower tube of involucre 2 – 8 mm wide ····· **C. sieboldiana** var. **sieboldiana**
1. Leaves orbicular-ovate, margin irregularly and coarsely serrate, apex mucronate-acuminate or caudate; lateral

veins (6)7 – 8(10) on each side of midvein ; tubular involucre more deeply divided into linear lobes, lobes (3)5 – 8(14) mm long ; narrower tube of involucre 3 – 12 mm wide ····· **C. sieboldiana** var. **mandshurica**

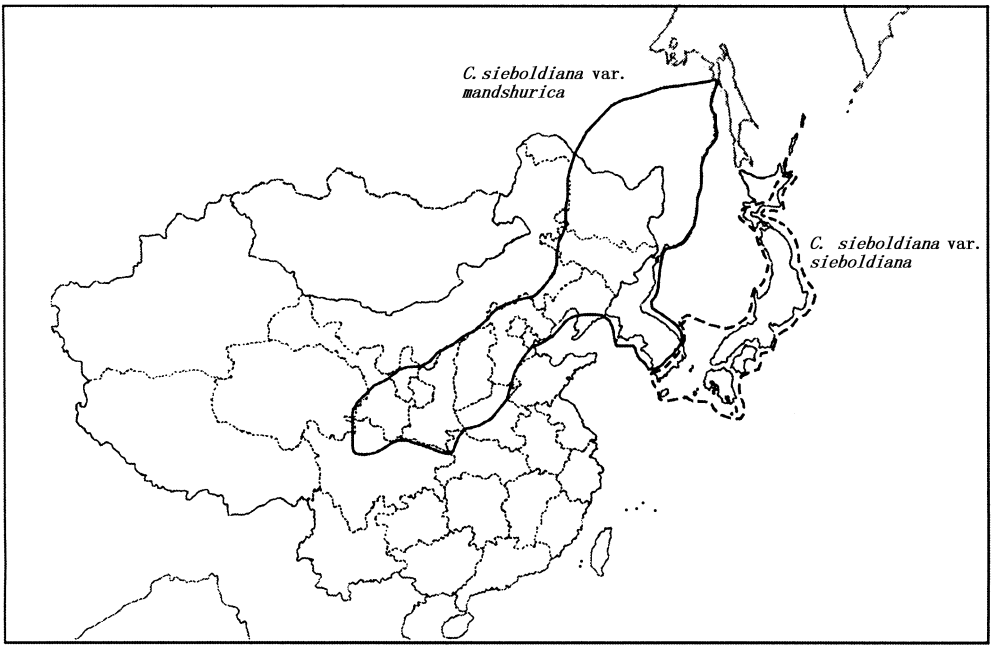

Fig. 7. Distributions of *Corylus sieboldiana* var. *mandshurica* and *C. sieboldiana* var. *sieboldiana* of eastern Asia. Adapted from Charkevicz, 1996 ; Fu et al., 2000 ; Ohwi, 1984.

4 Taxonomic treatments of *Corylus sieboldiana* complex

Corylus sieboldiana Blume in Ann. Mus. Bot. Ludg.-Bat. 1 : 310. 1850. —— *Corylus heterophylla* Fisch. ex Trautv. var. *sieboldiana* (Blume) A. DC., Prodr. Systematis Naturalis Regni Vegetabilis 16, 2 : 113. 1864. —— *Corylus rostrata* Aiton var. *sieboldiana* (Blume) Maxim. in Bull. Acad. Imp. Sci. Saint-Pétersbourg 27 : 538. 1882. Type : unknown.

Corylus rostrata Aiton var. *mitis* Maxim. in Bull. Acad. Imp. Sci. Saint-Pétersbourg 27 : 538. 1882. —— *Corylus sieboldiana* Blume var. *mitis* (Maxim.) Nakai in Bot. Mag. (Tokyo) 29 : 37. 1915. Type : Japan. Suruga, Mt. Fuji san, 1864. S. Tschonoski s.n. (isotype, A !, seen as a photo).

Corylus sieboldiana var. *brevirostris* C. K. Schneid. in Sargent, Plantae Wilsonianae 2 : 453. 1916. —— *Corylus brevirostris* (C. K. Schneid.) Miyabe, J. Fac. Agric. Hokkaido Univ. 26 : 458. 1934. Type : Japan. Hokkaido, O-shima, Shiribeshi San, 1914-08-27. E. H. Wilson 7268 (holotype, A !, seen as a photo).

Corylus hallaisanensis Nakai, Feddes Repert. 13 : 350. 1914.

Type : Korea. Querlpaert (= Island Jeju-do), Hallai-san (= Mt. Halla-san), forest, 1903-09, Taquet 333 (isotype, TI !).

var. *sieboldiana*

Distribution : Japan (Hokkaido to Kyushu), Korea (southern islands)

Representative specimens : **Japan. Aichi** : Kitasitara-gun, Toyone-mura, Chausu-yama, H. T. Im 3142-1 (Cheonnam National University). **Aomori** : Mt. Hakkoda, between Shimokenashitai

Moor and Sukayu Spa, Koji Yonekura 4265 (MAK); Nakatsugaru-gun, Iwaki-cho, H. T. Im 8243-1 (Cheonnam National University); Aomori-shi, Mt. Hakida-san, C. S. Chang 885 (SNUA). **Gifu**: Gujyo-gun, Takemura, Hirugano, G. Murata 14432 (MAK). **Gunma**: Agatsuma-gun, Takayaka Valley, T. Kawahara & M. Maki 5768 (TI). **Hokkaido**: Soraichi-sicho, Asibechu-si, Kirigisu-yama, H. T. Im & J. Murata 23125-1 (Cheonnam National University). **Kyoto**: Kitakuwada-gun, Chii-mura, Ashiu, Nakayama, S. Okamoto s.n. (MAK). **Miyazaki**: Higashiusuki-gun, Shiiba-mura, M. Hotta 6574 (MAK); Nishiusuki-gun, Gogasa-cho, Shiraiwatoge, Mt. Shiraiwa, H. T. Im 2865-1 (Cheonnam National University). **Nagano**: Mt. Hachinbuse, S. Momose s.n. (TI); Shimo-takai-gun, Tamanouchi-machi, Shiga Heights, Near Biwa Pond, M. Mizushima s.n. (MAK); Yamanakaku-mura, T. Togashi s.n. (MAK). **Okayama**: from Mt. Maruyama, 13 km to Mt. Daisen, Kawakami-son, Hidenobu Funakoshi 1348-1 (Cheonnam National University). **Shiga**: Ika-gun, Yogo-cho, H. T. Im 10510 (TI). **Tochigi**: Nikko, near Jakko-no-taki, J. Murata & H. Ohashi s.n. (TI). **Tokyo**: Nishi-tama-gun, Okutama-machi, Nippara, Mt. Tenso-zan, M. Mizushima s.n. (MAK); Hachioji-shi, from Katakura-cho and Kobiki-cho, H. T. Im & T. Kawahara 10462 (TI). **Yamanashi**: Mt. Fuji, Shuchi Noshiro 2759 (TI); Minamikoma-gun, Minobu-cho, Mt. Tenshigatake, Y. Kadota & J. Murata 3150 (TI); Minamisturu-gun, Mt. Mistutouge-yama, C. S. Chang 1398 (SNUA); Minamitsuru-gun, Kawakuchiko-cho, H. T. Im & C. S. Park 33939 (Cheonnam National University); Enzan-shi, H. T. Im 4750 (Cheonnam National University).

Korea. Jeollabuk-do: Mt. Baek-yang-san, T. Lee et al. 6290 (SNUA); Mt. Nae-jang-san, T. Lee et al. 6053 (SNUA), C. S. Chang 3657 (SNUA). **Jeollanam-do**: Gurye-gun, Mt. Ji-ri-san, Nogo-dan, T. Lee & C. S. Chang s.n. (SNUA); Mt. Jo-gae-san, T. Lee s.n. (SNUA); Island Hong-do, T. Lee s.n. (SNUA); Wando-gun, Island Wan-do, B. Yinger et al. 3449 (SNUA); Jaseong-gun, C. S. Chang et al. 3657 (SNUA); Gwang-yang-si, T. Lee s.n. (SNUA); Hwasun-gun, H. T. Im & C. G. Yang 21726 (Cheonnam National University); Sinan-gun, Zi-do, H. T. Im et al. 38363 (Cheonnam National University); Jangheung-gun, H. T. Im 34715 (Cheonnam National University); Gwangju, Dong-gu, Chiwon-dong, H. T. Im & C. S. Park 33881 (Cheonnam National University). **Gyonggi-do**: Yangpyeong-gun, Yong-mun-san, T. Lee s.n. (SNUA); Ong-jin-gun, Island Paekyong-do, B. Yinger et al. 2248 (SNUA); Uiwang-si, H. S. Oh & B. S. Mun s.n. (SNUA). **Cheju-do**: Cheju-shi, Odung-dong, J. Murata et al. 21054 (Cheonnam National University).

var. mandshurica (Maxim. & Rupr.) Schneid. in Sargent, Plantae Wilsonianae 2: 454. 1916. —— *Corylus mandshurica* Maxim. & Rupr., Bull. Acad. Imp. Sci. Saint-Pétersbourg 15: 137. 1856. —— *Corylus rostrata* var. *mandshurica* (Maxim. & Rupr.) Regel, Bull. Acad. Imp. Sci. Saint-Pétersbourg 15: 221. 1857. Type: Russia. Amur river, no date, C. J. Maximowicz s.n. (A !, seen as a photo).

Distribution: China, Russia, Korea, and Japan (Hokkaido).

Representative specimens: **Korea. Chungcheongbuk-do**: Jecheon-si, T. Lee s.n. (SNUA). **Chungcheongnam-do**: Mt. Goe-rong-san, T. Lee et al. s.n. (SNUA); Yesan-gun, Mt. Ga-ya-san, C. S. Chang s.n. (SNUA). **Gangwan-do**: Myongju-gun, H. T. Im s.n. (Cheonnam National University); Yangyang-gun. Osek-oncheon, Mt. Sul-ak-san, J. Murata & S. C. Ko 21072 (Cheonnam National University); Jeongsun-gun, H. T. Im 34919-1 (Cheonnam National University); Wonju-si, Socho-myeon, Mt. Chi-ak-san, C. S. Chang & J. I. Jeon 1884 (SNUA); Inje-gun, Mt. Jumbong-san, C. S. Chang et al. 3629 (SNUA); Yanggu-gun and Inje-gun, T. Lee et al. s.n. (SNUA); Yanggu-gun, C. S. Chang et al. BS052 (SNUA); Yeongwol-

gun, Jeon & H. S. Lee 11000 (SNUA); Goseong-gun, C. S. Chang et al. HR255 (SNUA); Hwacheon-gun, T. Lee s.n. (SNUA); Pyeongchang-gun, Dae-Gwan-ryeong, T. Lee & M. Y. Cho s.n. (SNUA); Pyeongchang-gun, C. S. Chang & J. I. Jeon 1984 (SNUA); Pyeongchang-gun, C. S. Chang & Choi 1608 (SNUA); Taebak-si, C. S. Chang & Kim 1904 (SNUA). **Gyeongsangbuk-do**: Mungyeong-si, Mungyeong-eup, C. S. Chang et al. UD005 (SNUA); Mungyeong-si, Mungyeong-eup, Jo-Ryeong, C. S. Chang & J. I. Jeon 1958 (SNUA); Mungyeong-si, Mungyeong-eup, T. Lee s.n. (SNUA); Mungyeong-si, C. S. Chang & Kim OJ019 (SNUA); Uljin-gun, D. R. Choi & S. M. Jang BA095 (SNUA); Yeongyang-gun, Jusan, D. R. Choi & S. G. Kwon JOO081 (SNUA). **Gyeonggi-do**: Pocheon-gun, Gwang-neung, T. Lee s.n. (SNUA); Anyang-si, T. Lee s.n. (SNUA); Inchon, Ganghwa-gun, T. Lee s.n. (SNUA); Yangpyeong-gun, C. S. Chang & J. I. Jeon 1831 (SNUA); Suwon-si, T. Lee s.n. (SNUA); Gapyeong-gun, C. S. Chang & J. I. Jeon 1904 (SNUA). **Jeollanam-do**: Jangsung-gun, H. T. Im 22218 (Cheonnam National University).

China. Heilongjiang: Yichun, T. Y. Ding et al. 2433 (IFP); Acheng, G. Z. Wang et al. 444, W. Wang et al. 785 (IFP). **Jilin**: Antu, T. N. Liou 3862 (IFP); Changbai, S. D. Zhao & S. Q. Zhong 2472 (IFP), S. X. Li et al. 733, 1005 (IFP); Fusong, T. N. Liou et al. 1271 (IFP); Hunjiang (Linjiang), S. X. Li et al. 1155 (IFP); Wangqin, P. Y. Fu et al. 862 (IFP). **Liaoning**: Benxi, W. Wang et al. 409 (IFP); Huanren, C. S. Wang 4126 (IFP), J. Y. Li et al. 1907 (IFP), S. C. Chang & Y. C. Zhu 214 (IFP), Y. C. Deng & K. Z. Wang 671 (IFP); Lingyuan, Exped. Team 178 (IFP); Qingyuan, C. S. Wang et al. 1210 (IFP).

Acknowledgements We thank Ms. Woo-Kyong Ahn for her assistance in the measurement of specimens. We would like to thank Drs. Akiko Shimizu at TI, Machio Wakabayashi at MAK, Hyung-Tak Im at Cheonnam National University, and Cao Wei at Institute of Applied Ecology, the Chinese Academy of Sciences, Shenyang (IFP) for loaning their collections of *Corylus*. We also thank the anonymous reviewer for providing helpful comments.

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Appendix. Origin and accession number for specimens utilized for morphological analysis.

C. sieboldiana var. *sieboldiana*

Japan. Aomori: C. S. Chang et al. 885 (SNUA); H. T. Im 8243-1, 8243-2, 10574, 23211 (Cheonnam National University); Mt. Hakkoda, between Shimokenashitai Moor and Sukayu Spa, K. Yonekura s.n. (MAK). **Aichi**: H. T. Im & J. Murata 3142, 3142-1, 3142-3, 3142-5 (Cheonnam National University). **Akita**: Tsubaki, Oga Peninsula, N. Satomi s.n. (MAK). **Fukushima**: Kashi, K. Sugawara s.n. (MAK). **Gifu**: Hirugano, Taka-su-mura, Gujyo-gun, Mino, Hondo, G. Murata s.n. (MAK). **Gunma**: Kawahara & Maki 5768 (TI); J. Murata & H. Ohashi s.n. (TI); Kyu-shikazawa, T. Yano s.n. (MAK). **Ishikawa**: Sue, Mii, Wajima City, N. Satomi s.n. (MAK). **Kyoto**: Nakayama in Ashiu, Chii-mura, Kitakuwada-gun, S. Okamoto s.n. (MAK). **Miyagi**: Mt. Kurikoma (Kurikoma Town), H. Ishikawa s.n. (MAK). **Miyazaki**: H. T. Im 2865-1, 2865-2 (Cheonnam National University); en route from Kubikukuri to Goyozan, Shiiba-mura, Higashiusuki-gun, M. Hotta s.n. (MAK). **Nagano**: Gofukuji, Matsumoto City, H. Okuhara s.n. (MAK); Tanaba, Omachi City, N. Kato s.n. (MAK); Lake Nojiri (Shinano Town), T. Yano s.n. (MAK); Near Biwa Pond, Shiga Heights, Yamanouchi-machi, Shimo-takai-gun, M. Mizushima s.n. (MAK); Yanaba, N. Kato s.n. (MAK). **Okayama**: Funakoshi 1348-1, 1348-2 (Cheonnam National University). **Shiga**: H. T. Im 10510, 10510-1, 10510-2 (Cheonnam National University); H. T. Im & J. Murata 4661 (Cheonnam National University). **Tochigi**: Nikko, Jakko, Takimichi, M. Ono & S. Ono s.n. (MAK). Shimotsuke, Nikko (Nikko City), T. Makino s.n. (MAK). **Tokyo**: H. T. Im & Kawahara 10462 (TI); Nippara-Mt. Tenso-zan, Okutama-machi, Nishitama-gun, M. Mizushima s.n. (MAK). **Tottori**: Mt. Daisen, N. Satomi s.n. (MAK); Mt. Kawanori, Okutama-machi, K. Suzuki s.n. (MAK). **Yamanashi**: C. S. Chang & H. T. Im. 1398 (SNUA); N. Shuichi 2759 (TI); Tateishi & J. Murata 3150 (TI); Yamanakako-mura, M. Togashi s.n. (MAK); Okura-takamaru, Yamato Village, Higashi-yamanashi Co., M. Tsuchiya s.n. (MAK); Mitsutoge Pass, Kai, K. Hiyama s.n. (MAK); H. T. Im & Park 33939 (Cheonnam National University). **Hokkai-do**: H. T. Im & J. Murata 4581, 4581-1, 4581-2, 23125-1, 23125-2, 23125-3 (Cheonnam National University).

Korea. Gyeonggi-do: B. R. Yinger et al. 2248 (SNUA). **Jeollanam-do**: T. Lee s.n. (SNUA); R. Dudley & B. R. Yinger 3449 (SNUA); H. T. Im 7335, 22218, 34715, 38363 (Cheonnam National University).

C. sieboldiana var. *mandshurica* (= *C. mandshurica*)

Korea. Gyeonggi-do: C. S. Chang & J. I. Jeon 1904 (SNUA); T. Lee s.n. (SNUA). **Gangwon-do**: C. S. Chang & S. Y. Choi 1608 (SNUA); J. I. Jeon & H. S. Lee 10973 (SNUA); C. S. Chang 3629 (SNUA); C. S. Chang & J. I. Jeon 1884 (SNUA); C. S. Chang & H. Kim 3016, 3021 (SNUA); C. S. Chang et al. 3644, HR 255, PA026, SM 051, SM 052 (SNUA); T. Lee s.n. (SNUA 7341), T. Lee s.n. (SNUA 7318), T. Lee s.n. (SNUA 7340), T. Lee s.n. (SNUA 7368), T. Lee s.n. (SNUA 7276), T. Lee & M.Y. Cho s.n. (SNUA), J. Murata & S. C. Ko 21072 (Cheonnam National University), H. T. Im 34919-1, 35008 (Cheonnam National

University).

China. Heilongjiang: T. Y. Ding et al. 2433 (IFP), G. Z. Wang et al. 444 (IFP), W. Wang et al. 785 (IFP). **Liaoning**: J. Y. Li et al. 1907 (IFP), S.C. Cui & Y. C. Zhu 214 (IFP), C. S. Wang et al. 1210 (IFP), C. S. Wang 4126 (IFP), W. Wang et al. 409 (IFP), Heilongjiang Exped. Team 178 (IFP), Y. C. Deng & K. Z. Wang 671 (IFP). **Jilin**: S. X. Li et al. 1155 (IFP), T. N. Liou et al. 1271 (IFP), S. X. Li et al. 733 (IFP), S. D. Zhao & Z. S. Qin 2472 (IFP), P. Y. Fu et al. 862 (IFP), T. N. Liou 3862 (IFP), S. X. Li et al. 1005 (IFP).

Intermediate form (= *C. sieboldiana* var. *sieboldiana*)

Korea. Gyeonggi-do: C. S. Chang & J. I. Jeon 1831 (SNUA), T. Lee & C. S. Chang s.n. (SNUA), T. Lee s.n. (SNUA), T. Lee, s.n. (SNUA), T. Lee et al. s.n. (SNUA), T. Lee s.n. (SNUA). **Gyeongsangbuk-do**: C. S. Chang & J. I. Jeon 1958 (SNUA), C. S. Chang s.n. (SNUA). **Jeollabuk-do**: T. Lee s. n. (SNUA), T. Lee s.n. (SNUA), T. Lee & C. S. Chang s.n. (SNUA). **Jeollanam-do**: T. Lee s.n. (SNUA), C. S. Chang 2982 (SNUA), T. Lee s.n. (SNUA), T. Lee & C. S. Chang s.n. (SNUA). **Chungcheongnam-do**: T. Lee & M. Y. Cho s.n. (SNUA).

毛榛复合体(桦木科)多变量形态学研究及分类学处理

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摘要 *Corylus mandshurica* Maxim. & Rupr. 和 *C. sieboldiana* Blume 在中国和俄罗斯一直被处理为独立的种。本文对来自不同标本室的这两个种的腊叶标本及野外采集的大量叶片进行了形态学分析,以确定形态分化是否足够成为建立种的依据。对采自中国、韩国和日本覆盖两个种分布区的 153 份标本的 18 个形态学性状进行了统计,以构建数据矩阵用于主成分分析。结果表明,包含 *C. sieboldiana* 复合体的数据单位(entities)在所有的形态学性状上均呈现出广泛的重叠区域。叶片和果实性状分析结果表明类群间缺乏分异性。基于形态学性状不足以把 *C. mandshurica* 从 *C. sieboldiana* 中分离出去,并给予种的等级,也就是说这两个类群在形态上没有完全分化,而且它们的分布区也是相连的。因此,应该把 *C. mandshurica* 作为 *C. sieboldiana* 的种下分类群处理。*C. sieboldiana* 在韩国南部和日本的具短总苞的植物常常被处理为独立的种或变种,但实际上应该作为 *C. sieboldiana* 内的变型处理,因为总苞性状高度变异,即使在同一个体上也是如此。

关键词 毛榛复合体;形态度量主成分分析;分类学处理